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Long-term Carbon Stabilization in Soils - The Role of Aggregates

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Beamline: U10B

Introduction: Despite the significant pool size of soil organic C within the global biogeochemical cycle, the dynamics of soil C and its controlling mechanisms are poorly understood. Plant litter or other organic inputs to soil first enter labile soil C pools and gradually become altered by soil microbial and fauna activity, and are then stabilized in so-called organo-mineral complexes. In addition, aggregation stabilizes substantial amounts of organic carbon in soils [1, 2, 3]. On the other hand, soil organic matter may also increase aggregation of finely textured soil, when high amounts of carbohydrates are present [4]. The extent of aggregate stabilization by soil organic matter may depend on its quality and on the mineralogy of the soil [3, 4, 5].

Methods and Materials: Samples were air-dried and sieved to pass 2mm. The synchrotron light source (Brookhaven National Laboratories, beamline U10B) provided the opportunity to analyze C forms in high spatial resolution of up to 5 micrometers. The effect of disturbance in natural grassland ecosystems on soil carbon forms was investigated. Entire aggregates were mounted on glass slides and cut open with a razor blade. In a second approach, the aggregates were embedded into elemental sulfur and sectioned to 1µm using an ultramicrotome (Leica, diamond knife). Small quantities of elemental S were melted and subsequently cooled to room temperature, and aggregates were introduced into the droplets in the super-cooled stage (L. Keller, personal communication, NSLS Science Highlight July 17, 2002, and [6]). Transmission, reflection and ATR Fourier transform infrared spectroscopy were used to compare C forms on the inside and outside of aggregates as well as map cross sections of aggregates. $SeCl_2$ windows were used with a thickness of 2mm and a diameter of 12.7mm (ISP Optics). IR microspectra were recorded using a Continuµm infrared microscope equipped with a motorized x-y stage and an MCT-A (4000-700 cm^{-1}) detector. The IR microscope is coupled to a Magna 860 Step-Scan FTIR spectrometer (Thermo Nicolet) and an internal DTGS-KBr detector. A digital camera is mounted to the microscope to enable optical imaging and recording of the areas investigated.

Results: The signal intensity of spectra obtained in ATR or reflectance mode were not sufficient to determine C forms in soil aggregates. Embedding of aggregates in sulfur droplets proved difficult to achieve once the sulfur cooled to room temperature, and high temperatures may alter the organic C forms. In contrast to successful efforts by L. Keller (personal communications) who embedded dust particles with diameters of less than 1 micrometer, we used soil aggregates of 20-1000 micrometers. The droplets crystallize very rapidly after contact with the aggregates and the material poorly fixed. Additionally, sectioning is more difficult in the poorly fixed particles, since the larger particles often contain quartz particles. Sections of aggregates obtained from a natural grassland site were investigated using 6 scans on the inside and outside of the aggregate, respectively (two scans shown in Fig. 1). Preliminary results indicate that signal intensities are higher near the edge than the inside of aggregates. C=O stretches appeared to be more pronounced inside the aggregates, whereas C-H bondages were dominant near the edge of the aggregates (Fig. 1). No C-H stretches were found inside aggregates. Embedding methods need to be improved to facilitate sectioning and avoid high temperatures during embedding. First data indicate significant spatial differences of C forms within aggregates.

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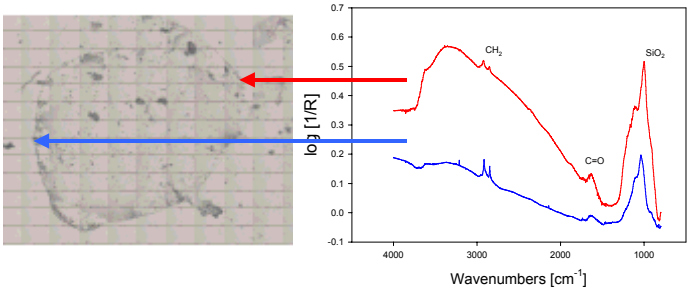

Fig. 1: FTIR spectra on the outside of an aggregate (1mm diameter).